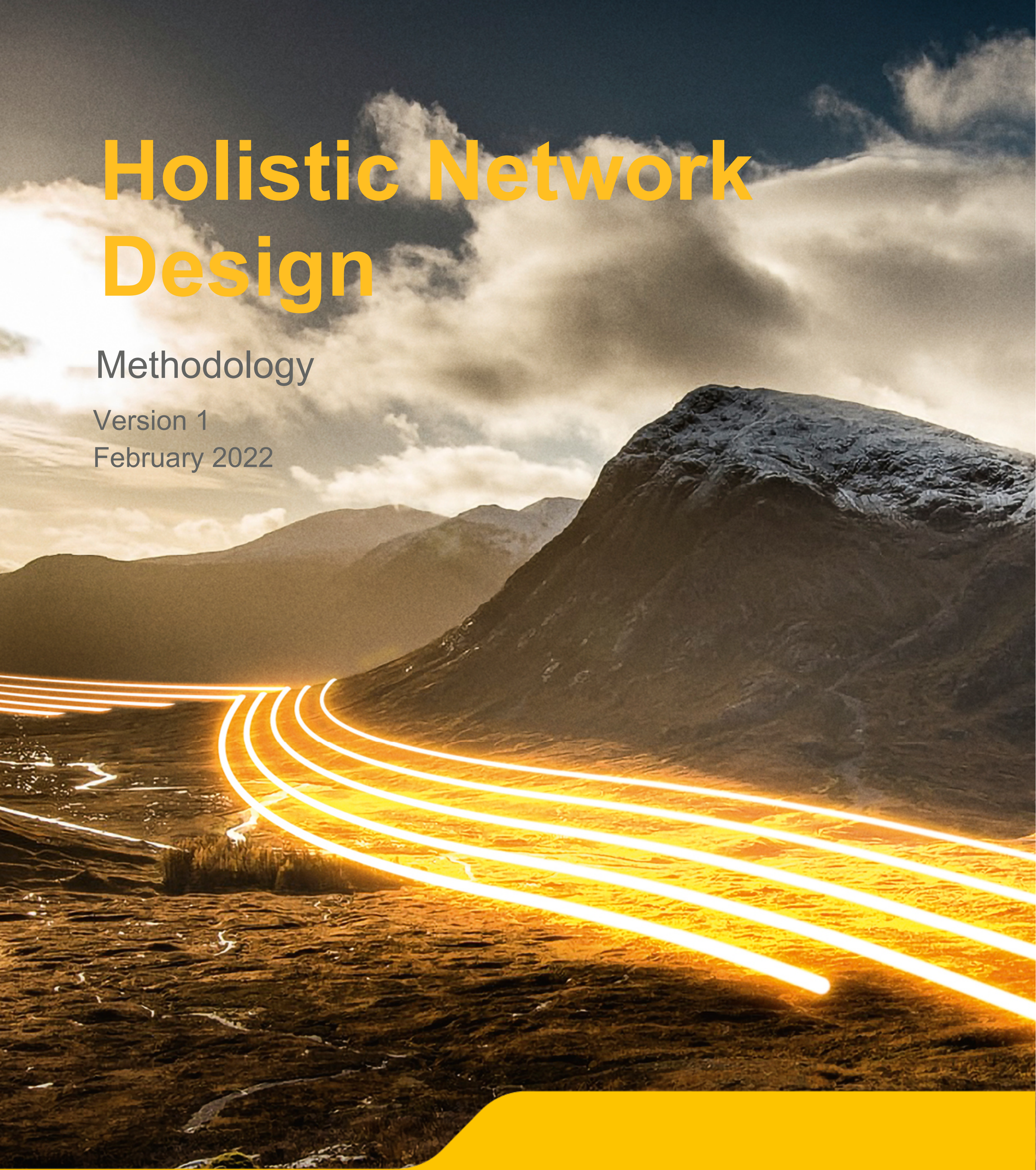
Holistic Network Design

Methodology

Version 1
February 2022



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Contents

How to read this document

Welcome to our Holistic Network Design Methodology document. This document aims to provide an overview of our approach to how we will deliver the Holistic Network Design (HND) that we are delivering as part of the Department for Business, Energy and Industrial Strategy's (BEIS) Offshore Transmission Network Review (OTNR). The executive summary provides an overview of the building blocks to deliver the HND; the full methodology document provides more detail on each of those blocks.

If you are a stakeholder that is part of the energy industry, the full document has been designed for you. The Executive Summary has been designed for all stakeholders and those who may require an overview rather than detail around each step being undertaken.

This document is the first version of the HND Methodology. The HND Methodology is part of a suite of documents, shown in Table 1 that will be published by National Grid ESO in June 2022. Updates to this document may be included in a version 2, published in June. The suite of documents provides a comprehensive overview of the HND for stakeholders.

Table 1 HND document suite

Document reference	HND document name
1.	Summary
2.	Options Appraisal & Recommended Design
3.	Industry Codes, Standards and Licence Recommendations
4.	Stakeholder Approach, Engagement and Feedback
5.	Methodology
6.	Glossary
7.	How the HND is meeting the CDG Terms of Reference

Executive Summary

Offshore wind has been identified as a critical technology in achieving net zero greenhouse gas emissions by 2050. To help realise this target, a step-change in both the speed and scale of deployment of offshore wind is required. One of the challenges to delivering the ambition for offshore wind deployment in the timescales required will be making sure that the offshore and onshore transmission network enables this growth in a way that is efficient for consumers and takes account of the impacts on coastal communities and the environment.

The ESO offshore coordination project, which contributes to the BEIS-led OTNR[1] , was set up in March 2020. Phase 1 of the project assessed the costs and benefits of a coordinated offshore network compared to the current radial connection approach. This assessment considered the technical considerations to achieve that, and how the offshore connections regime could change to drive greater coordination. In December 2020 we published our Phase 1 final report[2], with analysis indicating that:

- Adopting an integrated approach for all offshore projects to be delivered from 2025 has the potential to save consumers approximately £6 billion in capital and operating expenditure between now and 2050.
- There are also significant environmental and social benefits with an integrated approach, as the number of new electricity infrastructure assets, including cables and onshore landing points, could be reduced by around 50 per cent.
- However, this approach was conceptual and did not take deliverability into account. Delivering the extent of integration required in this timescale would be extremely challenging and potentially endanger the target of 40 GW of offshore wind capacity by 2030.
- An integrated approach for projects to be delivered from 2030, compared to the status quo, would deliver savings to consumers of around £3 billion and could facilitate a 30 per cent reduction in the new electricity assets associated with these offshore connections.

As part of Phase 2 of the project, BEIS and Ofgem requested that we deliver a Holistic Network Design (HND) for a coordinated onshore and offshore network. The HND will need to support the connection of 40 GW of offshore wind by 2030 in Great Britain, with 11 GW of that in Scotland as well net zero by 2050 for GB and by 2045 for Scotland.

The detailed scope of the HND is defined in the terms of reference set out by the OTNR project board. The terms of reference also set out **four design objectives**, that are to be considered during the design process. These objectives, shown in Figure 1, are to be considered on an equal footing:

Economic and efficient costs	The network design should be economic and efficient
Deliverability and operability	The network design should be deliverable by 2030 and the resulting system should be safe, reliable and operable
Environmental impact	Environmental impacts should be avoided, minimised or mitigated by the network design, and best practice in environmental management incorporated in the network design
Local communities impact	Local communities impacts are avoided, minimised or mitigated by the network design

Figure 1 Design objectives of the HND

The HND is being developed using a structured design approach created by National Grid ESO and in discussed with transmission owners, BEIS, and Ofgem. The design process consists of six key building blocks, shown in Figure 2:

[1] https://www.gov.uk/government/groups/offshore-transmission-network-review
[2] https://www.nationalgrideso.com/document/183031/download

1.Objectives and data	The project background is established with setting the design objectives and gathering the data to execute the method.
2. Interface points and design options	Involves the identification of the radial counterfactual design as well as a range of coordinated design options and corresponding interface points. The design options will consist of possible connections from offshore wind farms to interface points with the onshore transmission network, connections for offshore coordination, routes for cables and the onshore connections. These will be considered for appraisal.
3. Initial strategic options appraisal	This will be undertaken through an initial review of the options identified in the prior stage. This process will consider the environmental, community, technical and deliverability aspects of different design options.
4. Economic assessment	An economic optimisation modelling tool has been established as part of the HND to undertake this function, which allows capital and operational costs to be compared for multiple onshore and offshore network design options. The optimiser assesses all the design options produced from the options appraisal and produces the most economic design. Following the optimiser, alternative options will be considered to assess the sensitivity of the designs on cost and to ensure that the four design objectives are considered on an equal footing.
5. Final strategic options appraisal	The HND is required not only to consider an economically optimum design, but also to balance the other three design objectives of the OTNR terms of reference (operable & deliverable, environmental impact and social impact). The final design options will be compared, considering the four design objectives on an equal footing. This process will produce the final recommended design for the coordinated offshore network.
6. NOA refresh	The final step is to review and update the Network Options Assessment (NOA) process for the onshore network, embedding the coordinated offshore network in the background. This step will ensure the onshore network reinforcements recommended through the NOA complement the coordinated offshore network design.
HND	The final HND will consist of the coordinated offshore network design and the updated onshore network design.

Figure 2 Overview of HND process

The resulting coordinated offshore network design and onshore network designs will form the recommended HND. This will be published alongside the refreshed Network Options Assessment (NOA).

Considering the wide range of stakeholders impacted by the HND, BEIS requested that we use a Central Design Group (CDG) as a forum to consult the onshore transmission owners (TOs) and other stakeholders.

Introduction

Purpose

1. The purpose of the Holistic Network Design (HND) is to provide a coordinated onshore and offshore design for a 2030 network to meet government objectives of connecting 40 GW of offshore wind in Great Britain by 2030, including 11 GW in Scotland as well net zero by 2050 for GB and by 2045 for Scotland. The HND aims to provide an economic, efficient, operable, sustainable and coordinated National Electricity Transmission System (NETS) including the onshore and offshore assets required to connect offshore wind and considering international interconnectors.
2. The purpose of this HND methodology document is to provide an overview of the methodology that we are following and to show how the network design objectives are considered. As mentioned in 'How to read this document', the methodology document is part of a suite of documents that form the HND.

Background

3. Offshore wind has been identified as a critical technology in achieving net zero greenhouse gas emissions by 2050. In order to realise this target, a step-change in both the speed and scale of deployment of offshore wind is required. Delivering the ambition for offshore wind deployment in the timescales required will be a challenge and will rely on an offshore and onshore transmission network that enables this growth. The transmission network needs to be expanded in a way that is efficient for consumers and considers the impacts on communities and the environment.
4. The ESO offshore coordination project, which contributes to the offshore transmission network review (OTNR), was set up in March 2020. Phase 1 of the project assessed the costs and benefits of a coordinated offshore network compared to the current non-coordinated radial approach, the technical considerations to achieve such a network, and how the offshore connections regime could change to drive greater coordination.
5. In December 2020 the Phase 1 final report was published[3], with findings indicating that:
   - Adopting an integrated approach for all offshore projects to be delivered from 2025 has the potential to save consumers approximately £6 billion in capital and operating expenditure between now and 2050.
   - There are significant environmental and social benefits to an integrated approach, as the number of new electricity infrastructure assets, including cables and onshore landing points, could be reduced by around 50 per cent.
   - However, this approach was conceptual and did not take deliverability into account. Delivering the extent of integration required in this timescale would be extremely challenging and potentially endanger the target of 40 GW of offshore wind capacity by 2030.
   - An integrated approach for projects to be delivered from 2030, compared to the status quo, would deliver savings to consumers of around £3 billion and could facilitate a 30 per cent reduction in the new electricity assets associated with these offshore connections.
6. Following completion of Phase 1, BEIS and Ofgem asked the ESO to carry out further work as part of the OTNR. We are working closely with the OTNR project partners (The Crown Estate, Crown Estate Scotland, The Department for Environment, Food and Rural Affairs (Defra), Marine Scotland, The Marine Management Organisation, The Department for Levelling Up, Housing and Communities, Ofgem, The Welsh Government) and wider stakeholders to realise the economic, local and environmental benefits of a coordinated approach as identified in Phase 1. Our current work involves delivering the ESO-led activities of the OTNR across three workstreams and time horizons:
   - **Early Opportunities** – working with developers of projects that are fairly well advanced in their development, the TOs and other stakeholders to assess the costs, benefits and various

[3] https://www.nationalgrideso.com/news/final-phase-1-report-our-offshore-coordination-project

implications of projects that have put themselves forward to explore early coordination. Also identifying and progressing required changes to industry codes, standards and processes.

- **Pathway to 2030** – delivering a holistic network design for a coordinated onshore and offshore network to 2030 and assessing and progressing the required changes to relevant industry codes and standards.
- **Enduring Regime** – engaging with the Enduring Regime workstream of the OTNR, contributing to the discussion and development of relevant areas. This will be further shaped by the conclusions of the recent BEIS consultation[4] on the Enduring Regime and Multi-Purpose Interconnectors.

7. This document sets out the approach we have taken to our role within the Pathway to 2030 workstream and details the methodology being used to develop the HND.

8. This methodology has been developed based on the OTNR HND terms of reference (ToR) developed for the Pathway to 2030 work stream. The ToR is included in Appendix II of this document. The HND ToR, that has been agreed with the OTNR partners, sets out that the HND should provide the following:

   The ESO, in consultation with the CDG, will deliver an HND that ensures an economic, efficient, operable, sustainable and coordinated National Electricity Transmission System (NETS) (including onshore and offshore assets required to connect offshore wind) to present options, and a recommended HND for offshore connections works. This includes connections and associated strategic onshore infrastructure necessary to connect offshore generation in order to facilitate the pace and certainty required to deliver the 2030 offshore wind targets and the 2045 and 2050 net zero targets.

9. The HND ToR sets out four design objectives, which are to be considered on an equal footing:

- **Economic and efficient costs** – the network solution should be economic and efficient.
- **Deliverability and operability** – the network solution should be deliverable by 2030 and the resulting system should be safe, reliable and operable.
- **Environmental impact** – environmental impacts should be avoided, minimised or mitigated by the network design, and best practice in environmental management incorporated in the network design.
- **Local communities' impact** – impacts on local communities should be avoided, minimised or mitigated by the network design.

Engaging stakeholders in developing the design

10. The development of a coordinated onshore and offshore NETS impacts a wide range of stakeholders; therefore, stakeholder engagement is critical to the successful delivery the HND. Stakeholder feedback will be recorded throughout the development of the HND and will feed into a separate report (Stakeholder Approach, Engagement and Feedback) that will be published with the HND. The stakeholder engagement approach aligns with the HND ToR, that specifies which stakeholders should be engaged throughout the design process.

11. Although the HND is led by the ESO, several partners and stakeholders are engaged at regular touchpoints. A Central Design Group (CDG) consisting of representation from key stakeholders, including the transmission owners (National Grid Electricity Transmission, SP Transmission, Scottish and Southern Electricity Networks - Transmission), has been established to support the development of HND and ensure that stakeholder views are considered in the design. BEIS, Ofgem and the Scottish and Welsh Governments sit on the group as observers. The specific roles of the ESO, CDG and CDG subgroups are described below.

The ESO – responsible and accountable

12. The ESO, in consultation with the CDG, will deliver a design recommendation that ensures an economic, efficient, operable, sustainable and coordinated offshore and onshore NETS. The

[4] https://www.gov.uk/government/consultations/offshore-transmission-network-review-proposals-for-an-enduring-regime

design will include connections and associated strategic onshore infrastructure necessary to connect offshore generation in order to facilitate the pace and certainty required to deliver the 2030 offshore wind targets and the 2045 and 2050 net zero targets.

The CDG – consulted and informed

13. The CDG will act as a vehicle for the ESO to consult with transmission owners on the HND, and to consult with stakeholder groups as the HND is developed. The CDG members will meet on a periodic basis to discuss key design options and considerations. Four CDG subgroups, that align with the stakeholder engagement requirements set out in the HND ToR, have been established to focus on various objectives of the design. The CDG subgroups provide a focused forum to receive expert input and formal advice on specific elements of the design.

14. The following CDG subgroups have been established:

- **Stakeholder and communications subgroup** – the purpose of this subgroup is to enable the ESO to consult with the transmission owners and other stakeholders on communication and engagement plans for the delivery of the HND. This engagement helps to ensure clarity and continuity for wider stakeholders.
- **Commercial subgroup** – the purpose of this subgroup is to ensure the Industry Code, Standard and Licence Recommendations report comprehensively considers and provides advice on the commercial impacts of and interactions with the HND output, for example in respect of codes and connections.
- **Environmental subgroup** – the purpose of this subgroup is to bring together key environmental stakeholders that provide advice to the CDG on environmental impacts of the technically viable options being considered in developing the HND.
- **Developer forum** – the purpose of this group is to bring together in-scope developers to have collective discussions on the development of the HND.

Holistic Network Design process steps

Overview of process

15. The objective of the HND is to provide an economic, efficient, sustainable and coordinated NETS that supports the delivery of Great Britain's 2030 offshore wind targets. The approach for producing the HND needs to consider and compare multiple onshore and offshore design options including future generation and demand scenarios, the existing NETS and total capital and operational costs. Significant coordination and data transfer between each step in the design is required to deliver a holistic design.

16. The ESO has developed a structured design approach that considers the design objectives set out in the HND ToR. The design process consists of six key building blocks, show in Figure 3 that are required to produce the final HND.

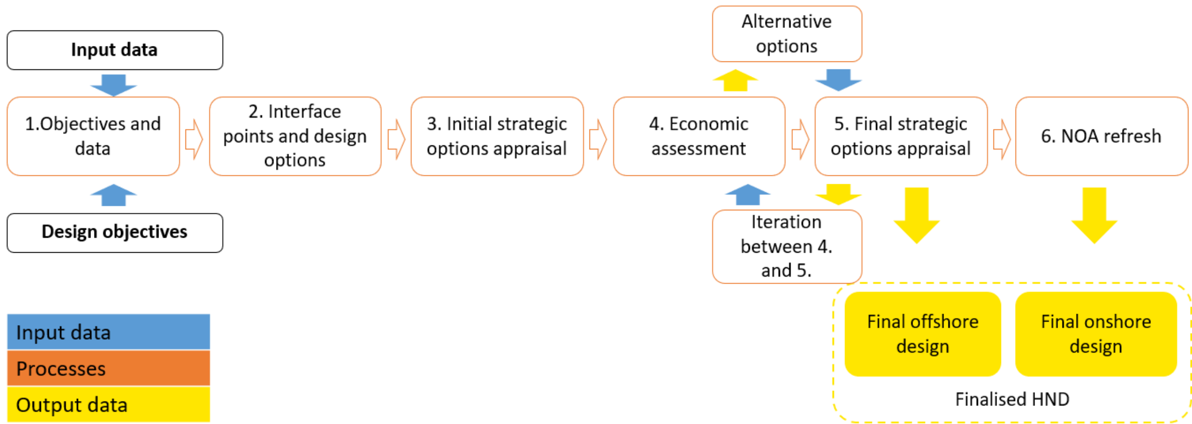

Figure 3 Overview of HND process

A brief explanation of each building block is provided in Figure 4.

1.Objectives and data	The project background is established with setting the design objectives and gathering the data to execute the method.
2. Interface points and design options	Involves the identification of the radial counterfactual design as well as a range of coordinated design options and corresponding interface points. The design options will consist of possible connections from offshore wind farms to interface points with the onshore transmission network, connections for offshore coordination, routes for cables and the onshore connections. These will be considered for appraisal.
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HND	The final HND will consist of the coordinated offshore network design and the updated onshore network design.

Figure 4 HND approach

17. The approach consolidates The Electricity Ten Year Statement (ETYS), the Network Options Assessment (NOA) and the offshore connections process to produce a holistic coordinated

offshore and onshore network design. The ETYS is our view of future transmission requirements and the capability of Great Britain's NETS over the next 10 years and the NOA is our recommendation for which reinforcement projects should receive investment. The final HND consists of a coordinated onshore and offshore network design. It may include various degrees of interconnection across wind farms and in some cases, it may include some radial connections. A more detailed schematic of the HND process is presented in Appendix I.

Defining objectives, approach and inputs

Figure 5 shows the initial step in the context of the overall HND process.

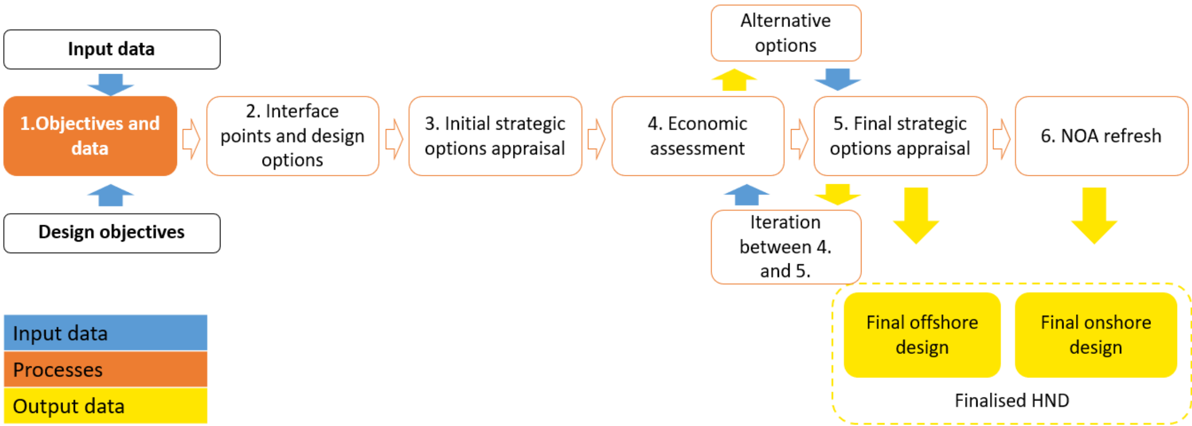

Figure 5 Step 1 - Defining objectives, approach and inputs

Approach to HND design objectives

18. The design objectives were set by the OTNR project board and documented in the HND terms of reference.
19. In developing the HND, we are seeking to minimise the whole system cost to consumers while also meeting network planning and operational standards and appropriately balancing local community, environmental and economic impacts to ensure clean, affordable and reliable energy to the consumer.
20. The approach taken for developing the HND and balancing the four objectives is an options appraisal process, where a robust methodology is used to compare different options. The appraisal assesses associated advantages and disadvantages of the options across a range of criteria.
21. We will initially identify and review technically feasible options that meet the offshore wind requirements. The options will be narrowed down through technical, strategic, and economic assessment to determine the recommended network design.
22. Each design objective will be considered on balanced judgement through the initial design option identification and strategic options appraisal process.
23. The comparison of options through the economic assessment and strategic appraisal will be an iterative process and the initial output of the economic optimisation will be refined through sensitivity analysis and consideration of alternatives. The recommended offshore network for the HND will be the combined outcome of the strategic options appraisal and economic assessment.

Establishment of HND data set

24. The first step in developing the HND is to establish the scope of the study and the background data sets required. This includes establishing the offshore generation in scope and developing a suitable generation background on which the NETS can be studied. The HND is using the 2021

Future Energy Scenario (FES) Leading the Way[5] to form the basis of the background for which studies and analysis are completed. The 2021 Leading the Way scenario has been modified for the purposes of the HND to align this scenario with the wind generation in scope for the HND and to be studied as part of the HND.

25. The design process will consider what onshore reinforcements may be required to enable the connection of the offshore generation that is being considered in the study. Specifically, we will use the NOA 2021/22[6] as an input to the economic assessment, noting that additional reinforcement will be proposed through the assessment process if required to meet network boundary capabilities.. A boundary splits the transmission system into two parts, crossing critical circuit paths that carry power between the areas where power flow limitations may be encountered[7]. In addition to the onshore reinforcement considerations, the economic assessment will use data on the costs of offshore network assets, and electricity market data to assess the cost of developing and operating the system in the future.

26. To address the environmental and community design objectives, the design will use GIS data from a range of sources to assess the impact of various options on the environment and communities.

27. For the purpose of developing the HND, the following datasets will be gathered:

- GIS maps;
- Environmental constraint data;
- Community constraint data;
- Technical constraint data;
- Generation maps and associated data[8];
- Future energy scenarios[9];
- NOA 2021/22 onshore reinforcement and boundary capabilities[10];
- Electricity market data;
- Forecast network demand;
- Interconnector flows;
- Onshore and offshore asset cost data; and
- NETS interface points.

[5] https://www.nationalgrideso.com/future-energy/future-energy-scenarios/fes-2021
[6] https://www.nationalgrideso.com/research-publications/network-options-assessment-noa
[7] For more information, visit https://www.nationalgrideso.com/research-publications/etys
[8] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1035655/otnr-generation-map.pdf
[9] https://www.nationalgrideso.com/future-energy/future-energy-scenarios
[10] https://www.nationalgrideso.com/document/233081/download

Identification of offshore design options and interface points

Figure 6 shows the second step, identification of offshore design options and interface points, in the context of the overall HND process.

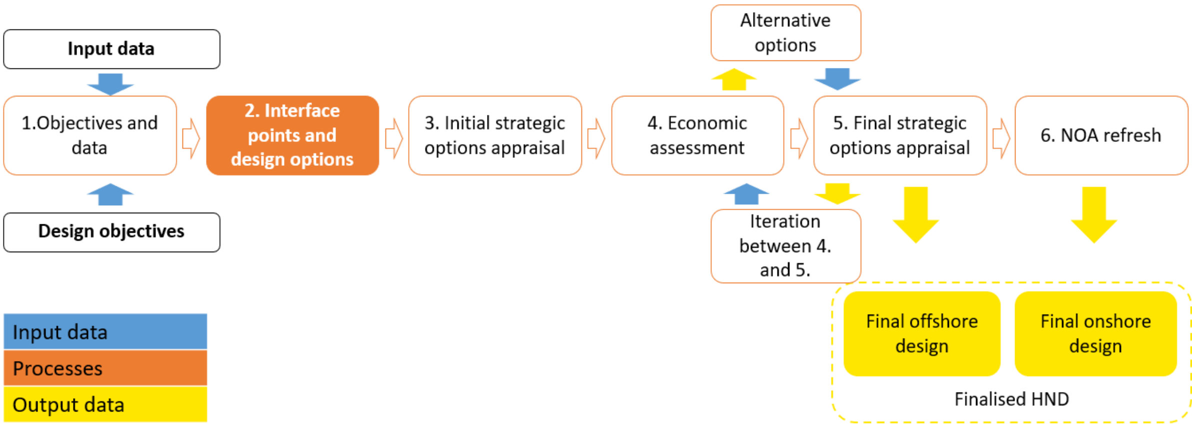

Figure 6 Step 2 - Identification of offshore design options and interface points

Approach to option identification

28. Once the in-scope generators and input data have been finalised, offshore designs and potential interface points for the connection of in scope generators connecting to the NETS will be developed. An interface point is a connection between the onshore transmission network and offshore transmission network. The aim of this process is to identify a long list of options for interface points and offshore designs and use a high-level appraisal process to refine this into a short list of options for initial appraisal. This short list will be progressed for initial appraisal, transmission owner modelling studies and economic assessment. The overall approach to options identification is summarised in the step-by-step process set out in Figure 7. This high-level appraisal will be carried out on a regional basis.

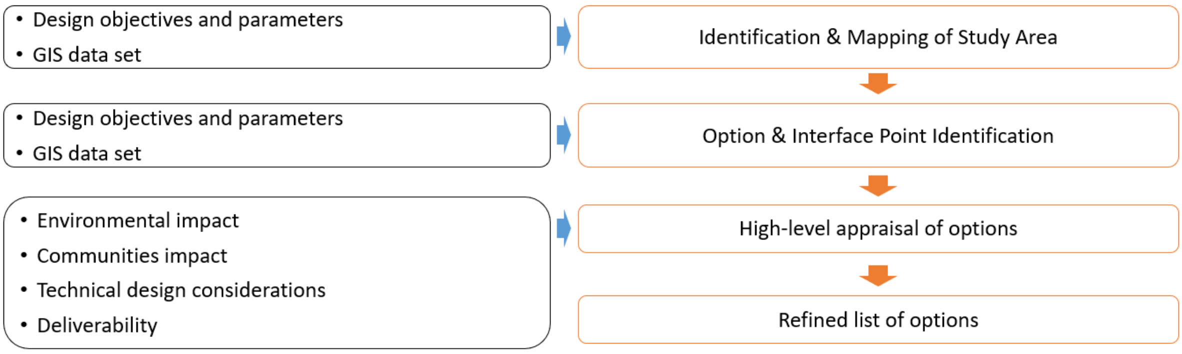

Figure 7 Options identification approach

Identification and mapping of study area

29. In the first step, several discrete study areas or regions will be established to cover in scope generators around the GB coast. The regions will be broad geographic areas around GB where generators are clustered. Network design options will be considered within each region. For each study area, relevant data sets gathered previously will be packaged accordingly to support detailed appraisal.

Identification of options and interface points

30. A number of design options, including transmission technology, offshore interconnection (in the coordinated scenario) and potential interface points, will be identified. These design options will consider technology readiness by 2030 and technical and commercial code requirements.

31. The interface points being considered within this study will be both new and existing transmission substations. A long list of potential interface sites will initially be identified by geographical proximity. Interface point sites will then be prioritised based on existing and potential future capability, local and wider network considerations and high-level environmental constraints. A refined list of potential interface sites will then be taken forward to high level appraisal.

32. These design options with associated interface sites will be considered regionally and appraised based on the four design objectives set out within the terms of reference (economical, deliverable and operable, community and environment impact).

High level appraisal of options

33. The objective of the high-level appraisal is to remove non-feasible options and refine the list of interface points and offshore design options to a preferred list of options which can be taken forward for initial strategic appraisal and system studies. At this early point in the HND process it is important to keep as many options in consideration as possible, only removing options which are considered least viable either technically, environmentally, or socially or where another comparable option is significantly more preferable considering all four design objectives.

34. A high-level BRAG (Black, Red, Amber, Green) assessment will be completed to refine the list of possible options. This BRAG assessment will consider the design objectives and compare options based on how they meet the four design objectives for the HND. Through this initial appraisal process some non-feasible options will be removed. More detailed BRAG assessments will be conducted during subsequent stages of the design and appraisal process.

Refined list of options

35. The options identification process and high-level appraisal provides a refined list of options to be taken forward for economic assessment and strategic options appraisal. This will include interface points and preferred offshore design options.

Initial strategic options appraisal process

Figure 8 shows step 3, the initial strategic options appraisal process, in relation to the other steps in the HND.

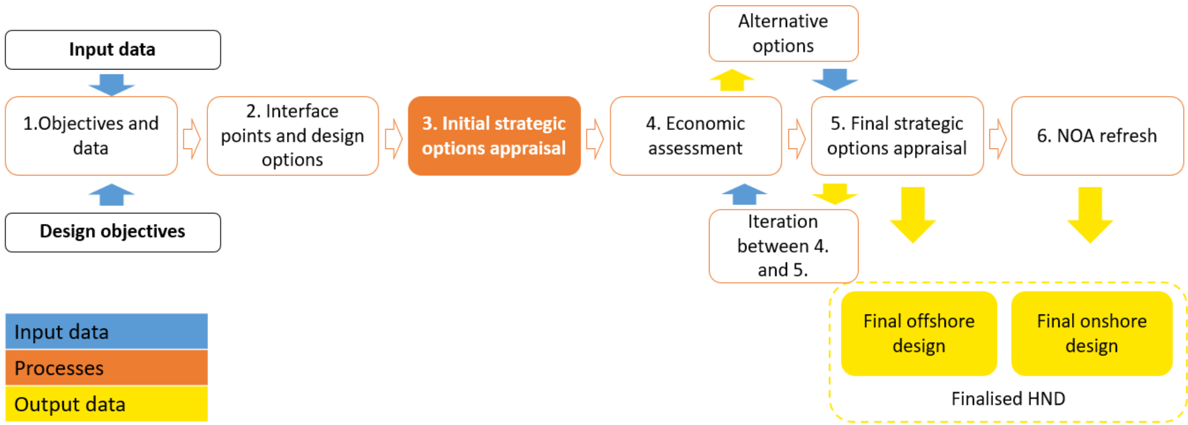

Figure 8 Step 3 - Initial Options Appraisal

Objective and input data of the appraisal process

36. The objective of the initial strategic options appraisal process for the HND is to enable the consideration of the potential design options against four design objectives on an equal footing. This step will ensure that decisions regarding the technology choice and location of infrastructure projects are based upon a better understanding of the implications of each alternative option. The process will provide a framework which allows technical, community, environmental and economic considerations to be identified and considered equally when selecting preferred options. The approach assists in decision-making and helps achieve an appropriate balance between the competing interests that must be taken into account in the development of the HND. Figure 9 shows how the initial options appraisal process integrates with the interface points and design options and the economic assessment.

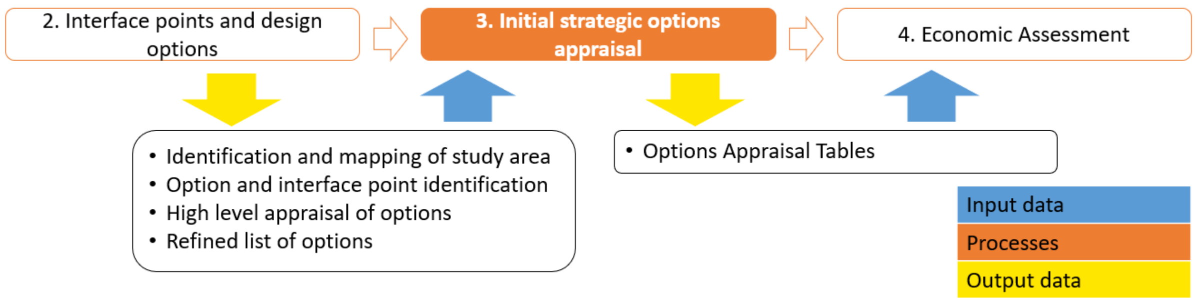

Figure 9 Initial options appraisal

Initial strategic appraisal – routing and siting

37. For infrastructure siting and cable routing the objective of this appraisal is twofold: determine feasible cable route corridors to an interface site; and assess the feasibility of a particular option, considering the locations of onshore and offshore infrastructure required. This is a high-level, desktop based, strategic options appraisal and is not intended to identify a route corridor for detailed network design, consenting and construction, or the final siting of any infrastructure, rather the purpose is to identify feasibility of options and to be able to compare different strategic options.

38. The route corridor and siting options will be appraised through a more detailed BRAG assessment. The appraisal will focus principally on environmental and community impacts and

technical considerations for the location and construction of required infrastructure. This step informs the strategic options appraisal stage where all the factors being consider in the options appraisal are brought together in option appraisal summary tables (OAST). Comparisons between options will be made by compiling the appraisal results in OAST and comparing the benefit of different options.

39. An initial appraisal will be completed for the cable route corridors and other infrastructure likely to be required within each option. The relevant features and/or constraints for each point-to-point offshore transmission connection will be appraised to provide a BRAG rating without mitigation. This will then be reviewed to consider what mitigation actions are feasible to reduce the impact of this feature or constraint and then a revised BRAG score considered. *Table 2* provides a description of the BRAG definitions being used for environment and community in this assessment.

40. The output of this stage is a list of potential route corridors with a completed work sheet assigned to each. The work sheet will contain a BRAG assessment for the relevant features and constraints. Each HND design option will be made up of different combinations of radial or coordinated connections between generating stations and interface points with the onshore NETS. The environment and community assessment of each option will be a summary of the BRAG assessments of each of the connections of which is the option is comprised. The initial option appraisal will be used to compare options and inform the selection of options for the economic assessment and strategic options appraisal.

Table 2 BRAG appraisal table

Ranking		Environment/Community
●	Black	Features or designations which affect the likelihood of an option being achievable to such a degree that the option should not be considered as part of the HND.
●	Red	Features or designations that are significant or pose a higher degree of risk to the design that they should be avoided which include: where potential mitigation (or compensation) is known; where the potential benefits to the design would clearly outweigh the potential issues and/or impacts; or where there are no alternatives.
●	Amber	The most protected features and/or areas that are likely to require detailed assessment and/or mitigation and should be avoided if possible.
●	Green	Features or designations to be taken into account in constraint assessment/study but which are likely to be capable of resolution.

Deliverability considerations

41. A key part of the appraisal will be to review the technical design options and consider their deliverability. This assessment will focus on identifying a reasonable earliest in-service date for each option, considering:

- Technical difficulty/complexity of construction, including potential risks and their impact on the implementation of a particular design option;
- HVAC/HVDC connections, as HVDC connections are less mature, supply is more limited, and installation and commissioning timelines are greater;
- Planning and consenting complexity; and
- Supply chain availability.

42. The deliverability considerations will be reviewed within a framework that determines the possible difficulties, risks and timelines for different aspects of the design. The purpose of the framework is to enable easy comparison of options.

Option appraisal summary & recommendations

43. The output of the initial appraisal process is an analysis of the implications of each option in the form of an options appraisal summary table (OAST). The options appraisal process is designed to provide a framework to support decision making and will primarily focus on the last three objectives: operable & deliverable, environmental & community. The first objective, to be economic and efficient, will be determined by the economic optimisation model which is described in the next section. An OAST will be prepared for each option, summarising that option with regard to the technical design, deliverability aspects, cost, environmental & social considerations (offshore, landfall, onshore, transmission owner). The OAST will provide a summary of the main factors that have been considered in reaching a conclusion for each option.

44. Once all the information has been brought together in the OASTs, a Challenge and Review workshop will be held internally and with the CDG to consider the options in detail. The Challenge and Review workshop will look at the options on a regional basis. The purpose of the Challenge and Review workshop is to review all of the appraisal work undertaken, to challenge judgements made regarding the effects of particular options and to compile an overall view of the relative performance of each option. Specific outcomes of the workshop will be shared with relevant stakeholders to provide their feedback. The assessment of the likely residual effect of the option on each receptor and technical benefit of each option is the main outcome of this process and will inform the overall appraisal on the performance of each option.

Economic assessment & technical studies

Figure 10 shows the economic assessment in relation to the other steps in the HND.

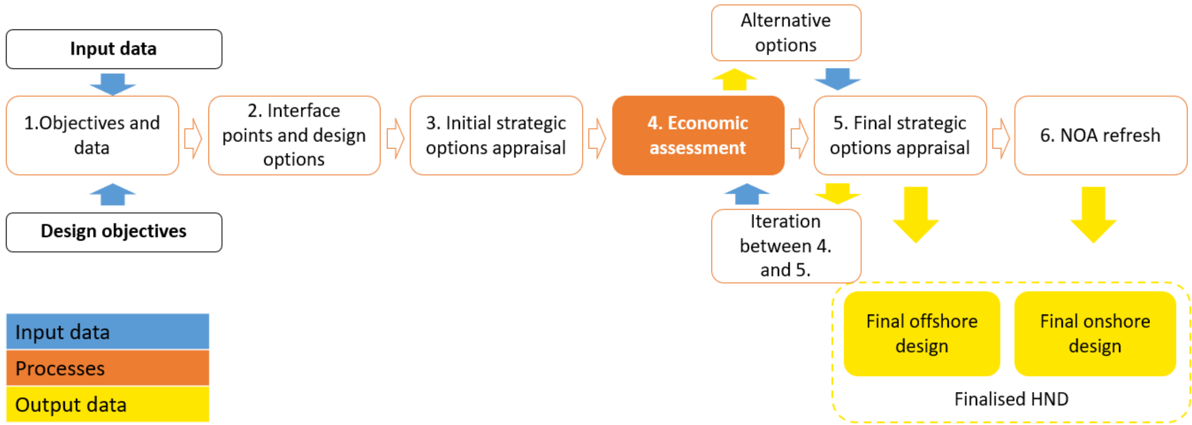

Figure 10 Step 4 - Economic Assessment

45. Figure 11 shows in more detail how the economic assessment fits within the HND process and the data flows involved. The initial options appraisal provides the design options and appraisal tables. The economic assessment then considers and calculates the optimal radial counterfactual and coordinated designs, including alternative options, which feed into the strategic options appraisal.

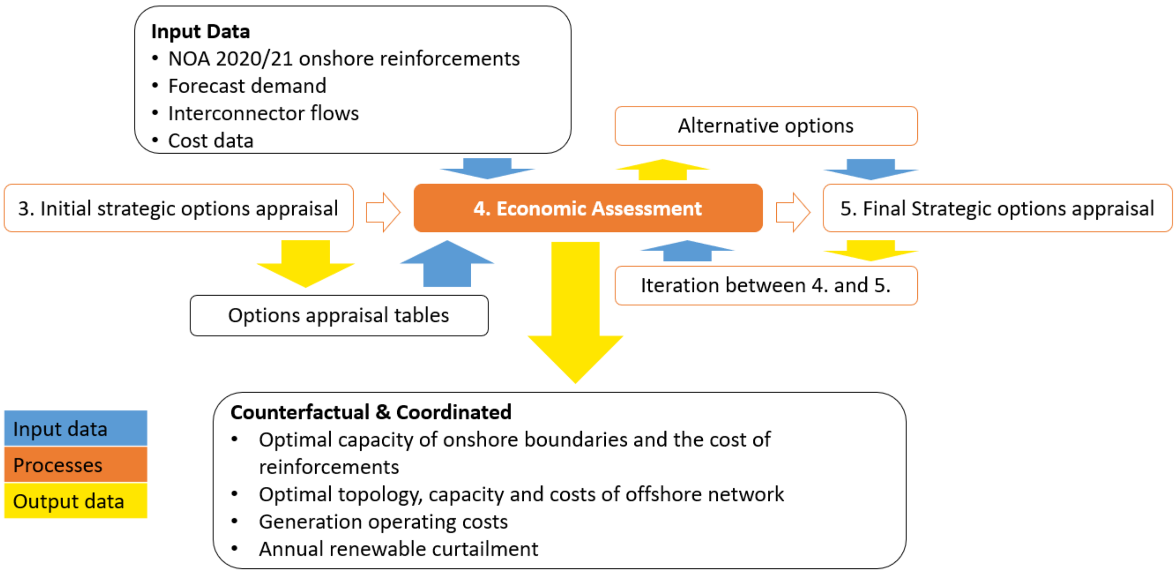

Figure 11 Economic Assessment

Economic optimisation model inputs

46. The HND aims to coordinate the connection of offshore wind farms through an offshore and onshore coordinated transmission network, thus achieving large capacity increases in offshore generation without uneconomic increases in network reinforcement and constraint costs.

47. The following data sets are key inputs to the economic optimisation model as outlined in the input and data collection:

- 2030 Generation Background (based on the FES 2021 scenario Leading the Way);
  - Electricity market data;
  - Demand;

    - Interconnector flows;
- Offshore design options;
    - Network capability and associated costs;
    - Technology types;
    - In-scope wind farms;
    - Interface points and associated costs;
    - Potential offshore coordination routes;
- Onshore network;
    - Network boundary capabilities;
    - Different onshore network reinforcements from NOA 21/22 and associated costs;
    - Further onshore reinforcement options; and
    - Onshore network studies.

48. The existing transmission system will be studied to understand the impact of the new generation on the network. These studies will help determine what reinforcements may be required to connect the new generation to the network. The work will also determine the infrastructure required at the interface site to enable the connection of the new generator. These studies will be undertaken by the relevant transmission owner.
49. The output of these studies will provide important input data to the economic assessment model. It will identify a connection point for the new generator, an earliest in service date and the cost for the interface point connection. This information will be used to inform the economic assessment and the strategic options appraisal.

Modelling approach

50. The model acts as an economic optimisation tool by choosing the optimal interface site, connection designs and network topology for both the radial counterfactual and coordinated offshore and onshore transmission networks.
51. The approach follows four steps:
    - Radial counterfactual design;
    - Coordinated design;
    - Least cost design; and
    - Alternative designs.
52. Connecting large capacities of offshore wind into the NETS presents challenges around the network boundaries. Network boundary transfer capability may not be sufficient in certain areas and therefore network reinforcement will be required. The economic optimisation process calculates the onshore reinforcement that would be required for each option. It weighs the offshore network provided by the options matrix against onshore network requirements, considering generation and demand profiles. This is calculated by constantly assessing NETS boundary constraints, wind curtailment and total asset and operational costs.
53. Figure 12 shows a high-level description of the inputs and outputs of the economic model. Note that in this case 'optimal' means the least cost design.

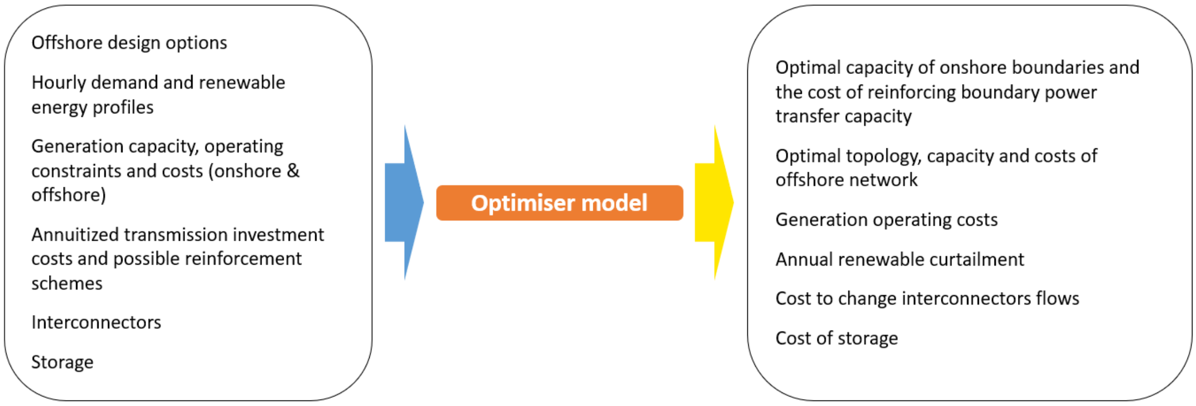

Figure 12 Optimiser Model

54. The optimiser minimises the overall annuitized cost of the network, including operational costs, associated carbon costs for thermal plants, constraint costs, curtailment costs, storage costs and costs associated with interconnector flows. The model satisfies power balance for each considered period i.e. generation, including interconnection and storage, must be equal to demand, and selects connection options such that all in scope offshore wind farms must be connected.

Radial counterfactual design

55. The aim of the radial counterfactual design is to enable the evaluation of the benefits of a co-ordinated design relative to a radial design produced on an equivalent basis. It investigates what would happen under the status quo situation if radial counterfactual designs are optimised to reduce capital expenditure (CAPEX) and operational expenditure (OPEX). The product of this analysis is an optimised offshore transmission radial design, onshore interface costs, onshore network reinforcement schemes, and the associated costs.

Coordinated design

56. The economic model is then applied to both the counterfactual radial design and coordinated offshore design options identified in the initial strategic options appraisal process (step 3). The economic model informs which reinforcement options to consider and provides offshore transmission system parameters, including capacities of links, types of link and landing points from the option provided. Offshore coordinated designs are optimised to reduce CAPEX and OPEX. The product of this analysis is an optimised coordinated design and the associated costs.

Optimised design

57. The radial counterfactual and coordinated designs are then compared to identify the benefit of the coordinated design and identify a final optimal design. It may be the case that in some areas the radial coordinated design provides the most optimal economic solution.

58. The final output from the optimiser is the most economic offshore design and the associated onshore reinforcements considering operational and capital network costs. The outcome of the economic modelling will be considered in further strategic options appraisals. The economic model will be run multiple times to consider alternatives identified during the strategic options appraisal to ensure that the most economic offshore design and associated onshore reinforcements are identified in the whilst being considered in the context of the four design objectives. This will be an iterative process of running the optimiser and conducting a strategic options appraisal to determine final designs.

59. The final designs will them be modelled in the flow modelling tool PowerFactory to validate the steady state operating points. Dynamic studies will be carried out on the offshore schemes to ensure operability and stability under a set of relevant fault and operational scenarios.

Security and quality of supply standard, and network studies

60. The recommended coordinated design will be studied to ensure the recommended design is operable and fit for purpose. This is important as deliverability and operability is one of the design objectives that needs to be considered. This study will involve a number of power system studies and assess consistency with the criteria set out in the security and quality of supply standard (SQSS) criteria.

61. The network studies involve ensuring the whole system can operate securely within acceptable margins when faced with disturbances outside normal operation. The studies will confirm the adequacy of the assumptions over the post-fault set-points and the performance requirements from the transmission assets (e.g., control settling times).

62. SQSS rules govern the security of the transmission network from real time operation through to long term planning. In developing the optimised network design, some deviations from the current SQSS rules may prove to be efficient. The current SQSS for offshore generators has mostly been applied to radial connections as this is the current industry practice. However, in coordinated designs, multiple generators (e.g. windfarms) may share high voltage direct current (HVDC) or high voltage alternating current (HVAC) systems and offshore elements may become part of the Main Interconnected Transmission System (MITS)[11]. The current SQSS does allow for co-ordination however it may benefit from review to reflect the latest technology and design options.

63. The SQSS infeed loss for planning and operating an offshore transmission system governs the maximum allowable disconnection of generation allowed. For the coordinated design the infeed loss will be increased from 1320MW to 1800 MW for normal infeed loss risks. This increased infeed loss allows for a larger, more efficient design without negatively impacting customers. The effect of the increase will be assessed as part of this analysis.

64. Tests on the optimal size of offshore network capacity will be conducted. This will include sensitivity analysis on the security of transmission lines using single circuit (N-1) and double circuit (N-2) redundancy criteria where applicable and the costs associated. Subsequently, fault conditions i.e. unplanned network outages, will be studied to determine the least cost allowed for the loss of this optimal capacity and how it is affected by failure or faults in any of the design components (e.g. platforms, circuits). These studies will inform what SQSS or technical code changes may be needed to enable the optimised designs.

Alternative designs

65. The economic optimiser is designed to minimise the costs of the network and produces one result which is the most economic option. However, the design objectives of the HND are broader than just optimising cost. The results of the model will therefore be reviewed in the strategic options appraisal process (step 5) in order to balance the four design objectives equally. Alternative designs to the optimal economic design will be considered and compared against the most economic design to reach a final recommendation. The strategic option appraisal process for the HND will consider these alternative recommendations to ensure the final proposed design is robust and considers any sensitivities, enabling the four design objectives to be balanced effectively.

66. This will involve running additional optimisation calculations with the best options chosen by the CBA model removed. This will be repeated multiple times, removing different options to see how the costs change and to allow comparison of the most economic design with other design objectives. The following and potentially additional sensitivities will be considered and analysed:

- Sensitivity of cost between different options;
- Removal of environmental or socially sensitive options to understand the economic effect;
- The effect of delivery timelines on HND recommendations, considering alternative recommendations to enable more generation to connect by 2030;
- The impact and cost of delays to wind farm connections; and

[11] A MITS node is defined as a Grid Supply Point connection with 2+transmission circuits connecting at the site, or a node with more than 4 transmission circuits connecting at the site.

- Significant delivery risks and alternative recommended options will be reviewed and, where they exist, alternative recommendations will be considered.

Final strategic options appraisal

Figure 13 shows the final strategic options appraisal in the context of the whole HND process.

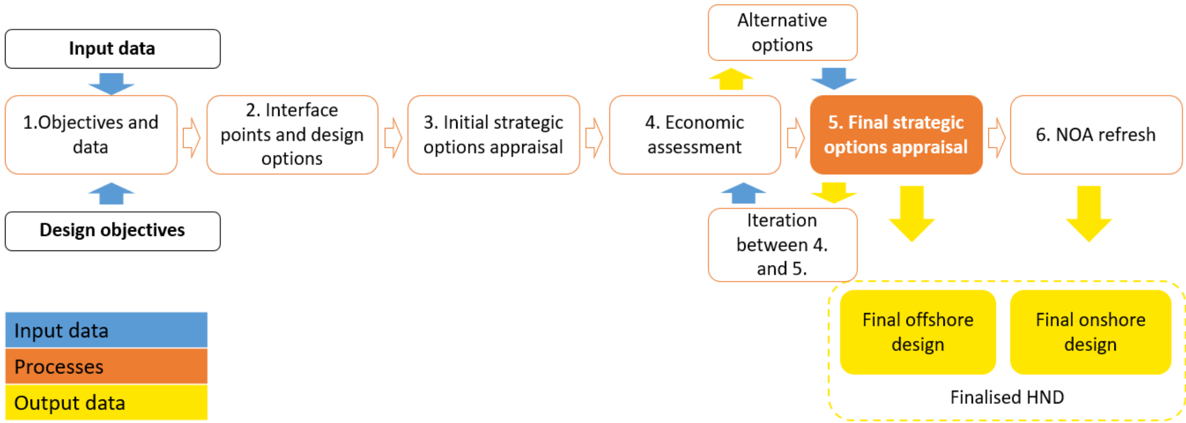

Figure 13 Step 5 - Final strategic options appraisal

67. The final strategic options appraisal follows the same process as the initial strategic options appraisal process in reviewing the options against the four design objectives. The process involves:

- Considering environmental and community impacts through the BRAG assessment;
- Assessing technical difficulty of each option; and
- Comparing the deliverability and operability of each option.

68. The purpose of repeating the process is to consider options on an equal footing against the design objectives; the design options selected by the optimiser and the alternative recommendations will be compared and appraised. This process will produce the final coordinated offshore design, balancing the four design objectives.

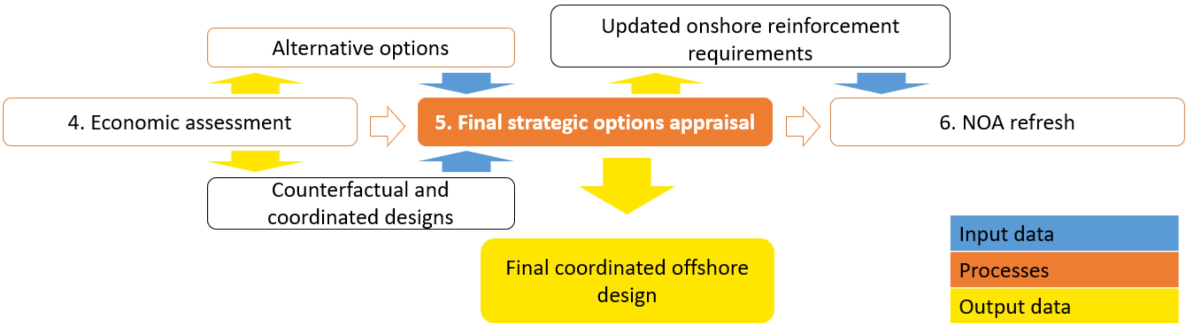

Figure 14 Final strategic options appraisal detail

69. The inputs to the strategic options appraisal are the designs from the economic assessment model and the initial appraisal. These designs will include the most economic design as identified by the optimiser model and, importantly, the alternative recommendations. The alternative recommendations are included to ensure that the four design objectives are considered on an equal footing, rather than cost being the single deciding factor.

70. The options will be appraised for a best fit with the four design objectives using all the data available, including the results of the economic model and the options appraisal data produced in the initial strategic options appraisal.

71. The strategic options appraisal will decide the chosen network design which will be put forward for the HND recommendation, pulling together the results of the appraisal process and the economic optimiser model.

Refresh of onshore reinforcements through the NOA process

The final step in the HND is the NOA refresh, which is shown in Figure 15.

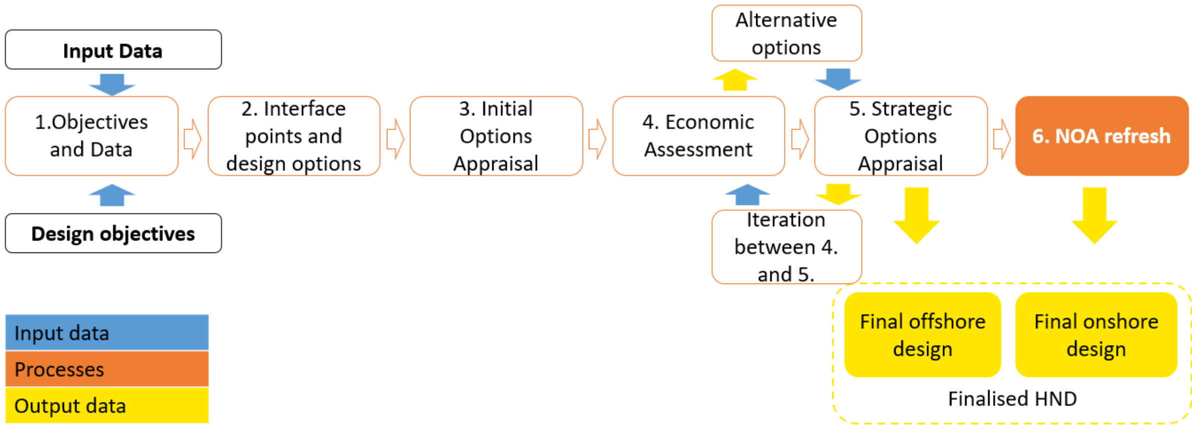

Figure 15 Step 6 - NOA refresh

NOA process

72. The Network Options Assessment (NOA) is a key ESO publication that recommends the major projects that are needed to deliver a transmission system that is fit for purpose to meet GB's net zero and green ambitions, whilst balancing the costs to end consumers. In principle, the aim of the NOA is broadly aligned with that of the HND. However, the NOA only considers the onshore system and focuses on cost rather than the four objectives of the HND. The NOA process therefore plays a fundamental role in the delivery of a HND and needs to be considered as part of this process.

NOA refresh

73. Ensuring consistency with the existing planning processes is a key consideration when developing the HND. The recommendations of NOA 21/22 provide the optimal level of onshore reinforcement against the FES 2021 without considering offshore coordination. This provides a robust starting point for the HND analysis as well as the radial counterfactual case. All reinforcement options submitted by the transmission owners and the ESO for NOA 2021/22 will be considered within the optimisation process that will determine the recommended coordinated offshore network design. Following the finalisation of the offshore design the onshore reinforcements required to facilitate economic and efficient transfer of power must be re-evaluated. This will be carried out by refreshing the NOA 2021/22 assessment with the offshore network design embedded within the study background. The refresh process will inform the transmission owners about which onshore options to further develop.

74. The primary input data to NOA refresh is the final coordinated offshore design which was identified in the strategic options appraisal. NOA 2021/22 was based on the 2021 FES which makes assumptions on the capacities and geographical locations of future generation, electricity and gas demand, and gas supply. The coordinated offshore network design will likely change the location of offshore connection points, thus impacting the energy flows around the country. This may have an impact on the required onshore network reinforcements which need to be re-assessed through the NOA process.

75. The refreshed NOA that will inform the recommended HND will align as close as reasonably practicable with the existing principles set out within the NOA methodology. However, the HND is an extension of existing planning processes, adding an extra dimension by considering the development of an offshore transmission network. Therefore, it is anticipated that some exceptions and deviations to the existing NOA methodology may be necessary. Where these

occur, they will be brought to the attention of and agreed with the NOA committee. The NOA methodology can be found on our website[12].

Onshore review output

76. The result of the NOA refresh process will be a fully optimised set of onshore reinforcement recommendations that complement the coordinated offshore design, thus forming the HND. The full impact on the NOA 21/22 onshore recommendations will be determined by the refreshed NOA which will be published alongside the HND. This review process will provide final onshore reinforcement recommendations which, along with the coordinated offshore design, form the HND.

[12] https://www.nationalgrideso.com/research-publications/network-options-assessment-noa/methodology

Recommended HND

77. The recommended HND will consist of the coordinated offshore network design and the updated onshore network reinforcements as identified through the revision of the NOA. One design option will be recommended, but where there have been challenges balancing the four design objectives, multiple options may be put forward. The HND will include:

- Interface points between the offshore network and onshore network;
- Coordinated offshore network; and
- Coordinated onshore network.

Recommendations for technical & commercial industry codes

78. In parallel to the work being undertaken to develop the HND, we are undertaking a review of technical and commercial industry codes and standards, and relevant licences, in consultation with the CDG. The aim of this review is to identify the impacts on codes, standards and licences that will arise as a result of the HND and any novel Network Design Models (NDMs) within the HND. We intend to publish an output from this review, in parallel to the publication of the HND, in the form of a report which sets out the expected impacts to codes, standards and licences and where feasible to make recommendations for how these challenges can be overcome.

79. We are actively engaging with the transmission owners and Ofgem on this via the CDG and the CDG Commercial sub-group, whilst working closely with internal colleagues within the Early Opportunities workstream and others within the ESO. We are also periodically engaging with external stakeholders and will continue to do so beyond report finalisation. This approach will ensure that learnings can be shared, and a consistent approach can be taken, with regards to overcoming the potential challenges posed by the HND and NDMs in relation to codes, standards and licences.

HND governance

80. The HND will follow a structured review process as shown in Figure 16. Once the final coordinated design and draft HND report are complete they will be reviewed internally within the ESO. The report will be updated based on feedback before sharing the final HND report with the CDG and OTNR governance. Following review and approval of the report by the CDG and OTNR project management board, the report will be published.

81. More detail on the offshore coordination project, including timelines, can be found on the ESO website.[13]

Figure 16 Governance process

[13] https://www.nationalgrideso.com/future-energy/projects/offshore-coordination-project/project-documents

Appendix

Appendix I - Detailed HND process outline

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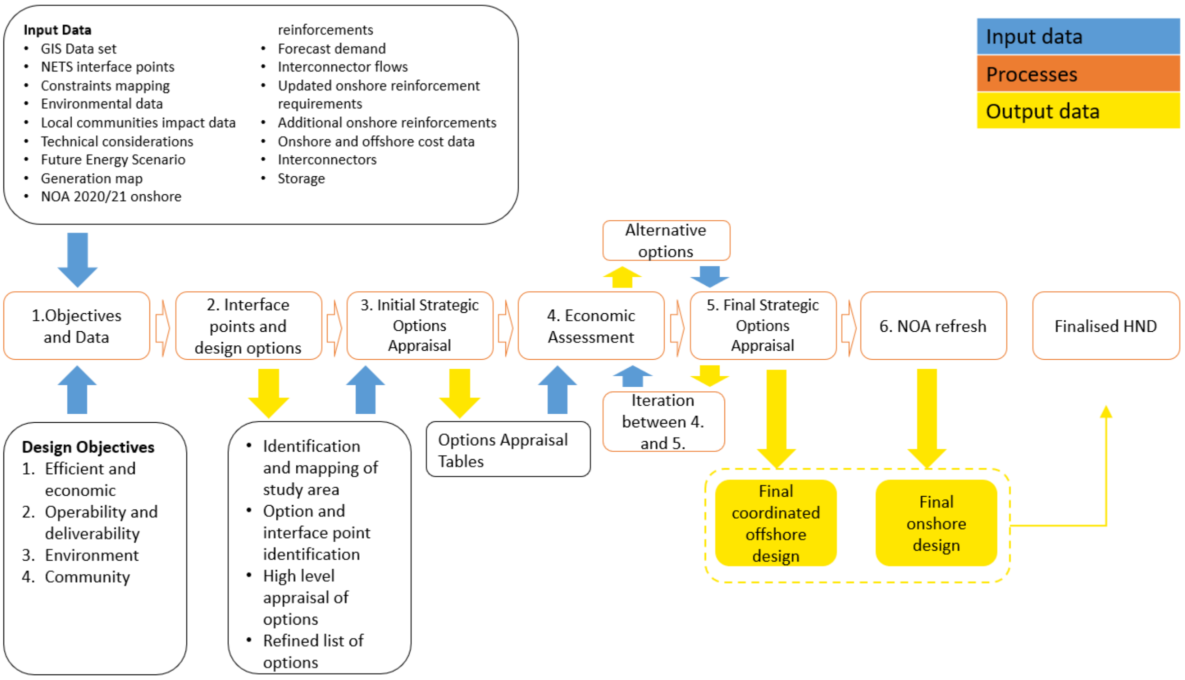

Figure 17 Detailed HND process outline

Appendix II - HND ToR

OTNR Pathway to 2030 Central Design Group and Network Design Terms of Reference[14]

1. Preamble to the Terms of Reference

- The Terms of Reference (ToR), including the Network Design Objectives, set out in the following document, in no way limit the prerogative of Ofgem or the Secretary of State to take decisions in their roles as independent decision makers.
- In particular, neither the ToR nor network designs developed on the basis of the ToR prejudge any decision, either:
  - By Ofgem, within the price control framework or on other matters,
  - By the UK Government, in particular BEIS and the Secretary of State, with regard to decisions on Development Consent Orders or on other matters, or
  - By the Scottish and Welsh Governments.
- In developing the Holistic Network Design (HND) and Detailed Network Designs (DNDs) (as described in this document), all parties shall have regard to the existing legal obligations placed upon them, including in particular their licence obligations.
- Ofgem is undertaking a wider Electricity Transmission Networks Planning Review (ETNPR)[15] in parallel to the work of the Central Design Group (CDG). Ofgem will coordinate the ETNPR and Offshore Transmission Network Review (OTNR) workstreams to ensure that emerging findings align and are compatible as far as possible, to avoid duplication or other process inefficiencies. This will include, for example, ensuring, as far as possible and appropriate, consistency in analysis and decision-making tools underpinning network plans and designs, as well as roles and responsibilities in developing those plans and designs – with the aim to ensure that the HND and DNDs are compatible with the wider network plans and designs resulting from the ETNPR (e.g., through the Network Options Assessment (NOA), the Large Onshore Transmission Investments re-opener or other mechanisms).
- The ToR and network designs developed based on the ToR are not intended to amend any existing frameworks and obligations (see outputs section on code or licence changes or derogations).
- If the OTNR Project Board approves the ToR, after they have been discussed by the OTNR Expert Advisory Group and the OTNR Working Group, the OTNR Project Board[16] will state its approval, and this will be noted in its session minutes, to highlight that the OTNR supports the ToR and the CDG carrying out its works based on the ToR.
- The ToR are only final when the OTNR Project Board has approved of them. However, the CDG can begin work, including stakeholder engagement, in advance of approval.
- Once the HND is completed, the Electricity System Operator (ESO), with the support of the CDG members as appropriate, will seek approval of the HND from the OTNR Project Board. This will happen after the design has been discussed by the Expert Advisory Group and the Working Group, and they are satisfied that the recommended design is in line with the requirements of the ToR. The Project Board will state that the HND is in line with the requirements of the ToR, and this will be noted in its session minutes, to highlight that the OTNR supports the HND

[14] The ESO are expecting a revised version of the ToR stating a change to the HND publication date now being June 2022.
[15] The aim of the ETNPR is to ensure that planning and design of the GB electricity transmission network can efficiently support the delivery of net zero at lowest cost to consumers. The ETNPR will review approaches to analysis and decision making, including for anticipatory investment and integration of market solutions, whole system solutions and flexibility to resolve network problems. The ETNPR will also review roles and responsibilities of key parties in early development of solutions, as well as review incentives and legal duties to enable any change. The scope of the ETNPR is broader than the OTNR and any changes to network planning arrangements as a result of the ETNPR may be taken forward after the Central Design Group has produced its initial outputs.
[16] For an overview on the OTNR governance fora please refer to slide 9 of this presentation: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/946574/presentation-17-10-20.pdf

2. Terms of Reference for the Central Design Group and Pathway to 2030 Network Design

Governance

1. Purpose

The HND will be delivered by the ESO in consultation with the CDG. The purpose of the HND is to support Government offshore wind targets of 40GW by 2030 for GB, including 11GW by 2030 for Scotland (Scottish Government target), as well as net-zero by 2050 for GB and by 2045 for Scotland (Scottish Government target).

The purpose of the CDG is to act as a vehicle for the ESO to consult and collaborate with Transmission Owners (TOs) on the HND, and to consult with stakeholder groups as the HND is developed.

2. Objective

The ESO, in consultation with the CDG, will deliver an HND that ensures an economic, efficient, operable, sustainable and coordinated National Electricity Transmission System (NETS) (including onshore and offshore assets required to connect offshore wind) to present options, and a recommended HND for offshore connections works. This includes connections and associated strategic onshore infrastructure necessary to connect offshore generation in order to facilitate the pace and certainty required to deliver the 2030 offshore wind targets and the 2045 and 2050 net zero targets.

Through considering the requirements for the NETS holistically, the HND should be economic and efficient, be deliverable and operable, minimise the impact on the environment, and minimise the impact on the local communities.

For the avoidance of doubt each of these objectives have equal weight.

There are two parts of network design for both onshore and offshore as further described in Part B and Part C:

- HND, and
- DND

3. Inputs - A non-exhaustive list of inputs for the HND are listed below:

- Generation Map,
- NG ESO 2021 Future Energy Scenario (FES) elements that meet net-zero targets for 40GW of Offshore Wind by 2030 and meet future net-zero targets,
- NOA January 2021 infrastructure assumptions against 2020 FES Leading the Way analysis,
- The draft revised National Policy Statements for Energy Infrastructure.
- The Network Design Objectives (see below section D) for the HND,
- TCE East Coast Spatial Grid Study, English marine plans, and Marine Scotland Sectoral Plan,
- Inputs from other stakeholders (including environmental stakeholders) to contribute to the overall CDG objective,
- Cost Benefit Analysis (CBA) methodology to reflect objectives and (as far as is appropriate) consistent with existing arrangements, e.g. NOA,
- Industry technical and commercial codes and standards, and
- Existing network design rules based on the Security and Quality of Supply Standards (SQSS) to guide the HND.

4. Output

- Recommended HND, including any notable HND variations,

- Proposed network design rules based on the Security and Quality of Supply Standards (SQSS) to guide the HND, and
- Recommended changes to industry technical and commercial codes, standards and licence, or derogations the CDG considers are required in respect of the HND and proposals. This could include the trialling of any innovative approaches pending changes or derogations.

5. Logistics

- The CDG meets at appropriate frequency to deliver outputs by agreed deadlines.
- The CDG can decide to form sub-groups as appropriate; sub-group governance should be consistent with the CDG's governance.
- At time of writing, there are the following sub-groups:
  - HND working level sub-group,
  - Environmental sub-group,
  - Commercial sub-group, and
  - Stakeholder & communication sub-group.
- Options for virtual attendance will be available for all sessions.

6. Membership and attendees

Members:

- Representatives of the ESO, National Grid Electricity Transmission, Scottish and Southern Electricity Networks Transmission, SP Energy Networks, and
- Parties responsible for delivery of offshore infrastructure, once known.

Observers:

- BEIS and Ofgem representatives, and
- Representatives of the Devolved Administrations.

Guests: The CDG can invite guests (including in-scope developers such as those that have secured seabed leases through the Crown Estate Round 4 and ScotWind leasing rounds) on a case-by-case basis to provide input on specific topics.

The ESO will chair and provide a secretariat function for the meetings.

7. Delegates

Delegates must have appropriate authority to speak on behalf of their organisation.

1. Scope of work

a) HND timing

The ESO will deliver the final draft of the HND in January 2022, in consultation with the CDG.

b) HND content

- The HND must identify the requirements for network capacity on the NETS across GB and in offshore waters.
- The HND should as far as reasonably possible include indications on the potential location of infrastructure such as onshore landing points and locations of new substations, as well as technology type (e.g. AC vs. DC) and other key parts of the specification. It should provide developers with potential connection points and connection dates. The following additional points should be considered as part of this development:
  - The HND should include a robust CBA of the different options available. Noting the NOA and other CBA methodologies, the CDG will need to determine an appropriate CBA methodology against which to assess identified options, taking into account the four Network Design Objectives.
    - In practice, the HND will cover the appropriate onshore and offshore network. This includes the interface between what is currently considered the 'offshore' network (assets operated by an Offshore Transmission Owner today), and 'onshore' network (assets operated by a TO today).
    - For those elements of the HND on the 'offshore' side of this interface, the HND should provide as much detail as reasonably possible, while considering that the DND will then set out the next level of detail (see below), in terms of both the electrical and spatial configuration of assets. A robust CBA should be applied cognisant of, and consistent with, the RIIO-T2 price control frameworks.
    - For those assets on the onshore side of the interface, any element of the HND (and subsequent DND) that includes infrastructure that would typically form part of a future NOA should take its NOA treatment into consideration and the ESO should take reasonable steps that, while remaining consistent with the Network Design Objectives, HND proposals and the outcome of the NOA align and where this is not the case the differences are justified.
    - The associated assets would be subject to the relevant existing regulatory processes within the RIIO-2 price control. In order to facilitate the consideration of those assets in a timely and efficient manner, the HND should therefore provide information (e.g. electrical and spatial configurations, CBA) to the form and standard that would normally be expected under e.g. the relevant regulatory process.
  - The HND needs to consider the Network Design Objectives cost, deliverability and operability, environmental impacts, and community impacts on an equal footing.
    - In developing the HND, the ESO (in its independent role, including in relation to and within the CDG) should seek to minimise the whole system cost to the consumer of the NETS while also meeting network planning and operational standards. The ESO should also take into account the Network Design Objectives but taking due consideration that the HND needs to be an economic and efficient solution. Whole system costs must account for achieving the Government's net-zero targets, while appropriately managing social, environmental and economic impacts to ensure clean, affordable and reliable energy to the consumer. Where a different balance of Network Design Objectives (in particular of total cost vs. other objectives) would result in a very different HND, the ESO should make this clear as part of the recommendation process and if appropriate show alternative options.
- The HND should provide a sufficient level of detail to allow the parties undertaking the DND to make decisions about the specific Network Assets that would fulfil the requirements of the HND. The HND should include a number of "fixed" design components, but it should not limit the ability of the parties undertaking the DND to exercise their engineering judgement or limit their ability to discharge their detailed planning and consenting obligations.

c) Roles and responsibilities for the HND development

- The ESO will be responsible for making an independent evaluation of the HND, including carrying out the CBA.
- The ESO will be responsible for developing, delivering and owning the HND.
- In developing the HND, the ESO should work closely with the TOs and, if this is decided in time, the party responsible for delivery of the offshore DND, and take their views into account.
- If there is a divergence in opinion the ESO, the TOs and the other members of the CDG will seek to find agreement. If an agreement cannot be found, the ESO will take the final decision.
- The CDG should also take into account the views of developers and, as already stipulated by individual licences, environmental and community stakeholders, as far as is appropriate and reasonably practicable. This will include spatial planning, indicating where there are environmental constraints, land availability and interactions with other assets (including those not owned by TOs). In both cases the ESO should be able to demonstrate how those parties' views have been addressed within the final HND.

OTNR DND

1. Scope of work

- The DNDs for both offshore and associated onshore assets should set out the next level of detail for the Network Assets based on the requirements set out in the HND. The DND should also seek to address the key environmental and cumulative impacts, indicated in the HND and therefore include mitigations and other measures required under the existing legislative and regulatory obligations (e.g. Habitats Regulation Assessment or equivalent), as applicable.
  - The onshore DND should be at a level of detail that allows licensees to proceed with the delivery of Network Assets, such as the pre-consenting development phase and detailed technical studies.
  - Where the TO is progressing development of the infrastructure the DND should be of a level that allows the TO to make a submission to the appropriate RIIO-T2 mechanisms. If the TO thinks it will need to make a submission to trigger an uncertainty mechanism to build the respective piece of infrastructure, it should also provide an early indication of this to Ofgem.
- The TOs will undertake the onshore DND in their respective Licence Areas. It is hereby noted that some of the onshore infrastructure that will feature in the HND is already in the DND phase.

D. Interpretation

For the purposes of this document:

- Licence Area has the meaning given to it in the Electricity Transmission Licence.
- National Electricity Transmission System (NETS) has the meaning given to it in the standard conditions of the Electricity Transmission Licence.
- Network Assets has the meaning given to it in the Electricity Transmission Licence.
- Network Design Objectives are the ones listed in section E of this document.

#	Name	Description	Notes
1	Economic and efficient costs	Network solution is economic and efficient	• Taking into account, amongst others, whole system costs and the requirements of licence obligations • Least regrets investment decision that can be taken 'today', i.e., reinforcements that are required under all FES that are in optioneering to consultation stage in 2021 to meet a 2030 delivery
2	Deliverability and operability	Network solution is deliverable by 2030 and the resulting system is safe, reliable and operable	• The aim is that the coordinated onshore and offshore network infrastructure connects the Leasing Round 4 and ScotWind projects by 2030 consistent with achieving Government offshore wind targets of 40GW by 2030 for GB, including 11GW by 2030 for Scotland, while protecting system security, reliability and resilience. • Also, recommend reinforcements to manage constraints that are consistent with the Network Design Objectives. • Taking into account, amongst others, planning consent requirements, value for money to the consumer and commercial acceptability from developers • This objective likely interacts with environmental impact and community impact
3	Environmental impact	Environmental impacts are avoided, minimised or mitigated by the network design, and best practice in environmental management is incorporated in the network design	• Cumulative environmental impacts of the design should be considered in addition to impacts in isolation, i.e., a high level desktop assessment of key environmental impacts should be undertaken • Includes offshore and onshore environmental impacts, for example protected areas onshore and offshore, and further constraints • It should be considered that the connection of offshore wind as low carbon generation technology avoids carbon emissions compared to electricity generation with fossil fuels, but the HND should not inadvertently cause unnecessary damage to valuable ecosystems and contribute to biodiversity loss
4	Local communities impact	Local communities impacts are avoided, minimised or mitigated by the network design	• Encompasses onshore and offshore communities, and wider onshore communities hosting strategic grid infrastructure • Addressing the concerns of local communities which typically relate to: The number and size of onshore connection points and onshore infrastructure; cumulative impacts associated with multiple connections, substations and other infrastructure; onshore transmission reinforcements driven by offshore infrastructure connections. Co-ordinated/consolidated/ integrated infrastructure is central to mitigating impacts. •

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